FuzzyNet Online

Application Notes

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Glass Melting Furnace Temperature Control

INTRODUCTION

Temperature control is widely used in various processes. These processes, no matter if it is in a large industrial plant, or in a home appliance, share several unfavorable features. These include non-linearity, interference, dead time, and external disturbances, among others. Conventional approaches usually do not result in satisfactory temperature control.

In this Application Note we provide examples of fuzzy logic used to control temperature in several different situations. These examples are developed using FIDE, an integrated fuzzy inference development environment.

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FUZZY CONTROLLER FOR GLASS MELTING FURNACE

A glass melting furnace has two rooms, a melter and a refiner. Raw materials are melted into glass at high temperature in the melter. The temperature of the melted glass is adjusted to a suitable temperature for the glass forming process to follow. It takes a long time to change the temperature in the furnace, which is an example of dead-time in this process. The flow of melted glass is not uniform, especially at the bottom of the furnace. In addition to temperature, other factors also contribute to the thermal characteristics of melted glass. Raw material mixing procedure, glass color, and the amount of the glass are some of the factors. Because there are many variables and the procedure complex, it is very difficult to design an effective temperature controller for this application using conventional control approaches.

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Control Objective

Control temperature in a dead time process such as in a glass melting furnace.

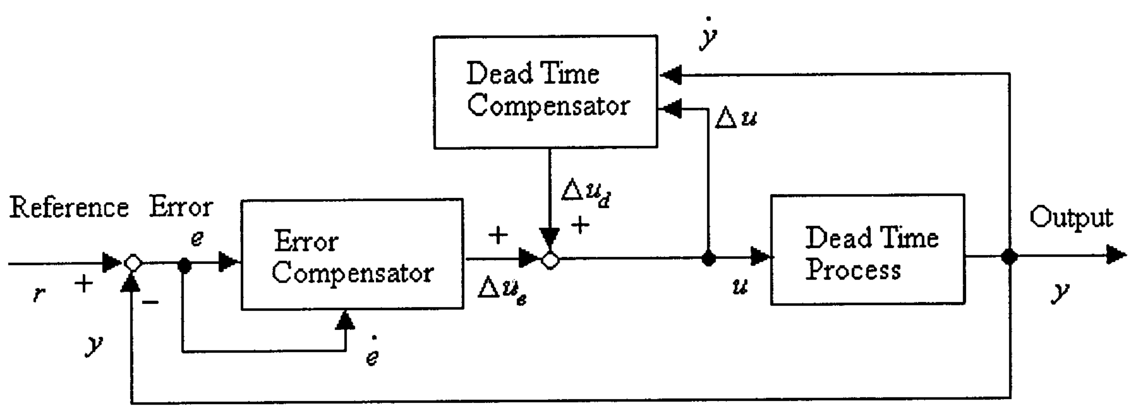
Fuzzy Control System

The control block diagram for a glass melting furnace is shown in Figure 1. Control value u is applied to the process to adjust the temperature. This value is changed by two compensators. The variation of u can be written as

$$\Delta u = \Delta u_d + \Delta u_e$$

where Δu_d is the output of the dead time compensator, and Δu_e is the output of the error compensator. The dead time compensator is used to reduce the effect dead time has on the process. Its output (Δu_d), an incremental change in control value, is derived from the change in the current and previous control value (Δu) and the time differential of output temperature ($\dot{e}$). The error compensator is used to reduce the difference between the desired temperature and the actual temperature of the furnace. Its output (Δu_e), also an incremental change in control value, is inferred from the difference(error) e and its time differential $\dot{e}$(actually the variation Δe is used). Δu_d and Δu_e are combined to change the control value u.

Figure 1 *Fuzzy Control for a Glass Melting Furnace*



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Input/Output Variables of the Dead Time Compensator

Labels and membership functions of input/output variables of the dead time compensator are shown in Figure 2a, 2b, 2c. The membership functions can be created by using the MF editor in FIDE.

Figure 2a *Labels and Membership Functions of Input Variable* ***Prev_Var_Ctrl***

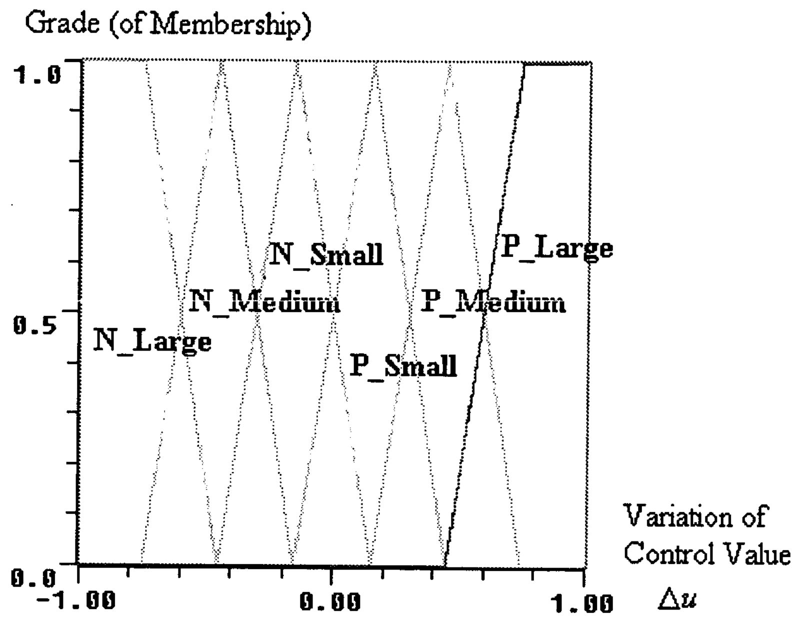


Figure 2b *Labels and Membership Functions of Input Variable* ***TimeDiff_Output***

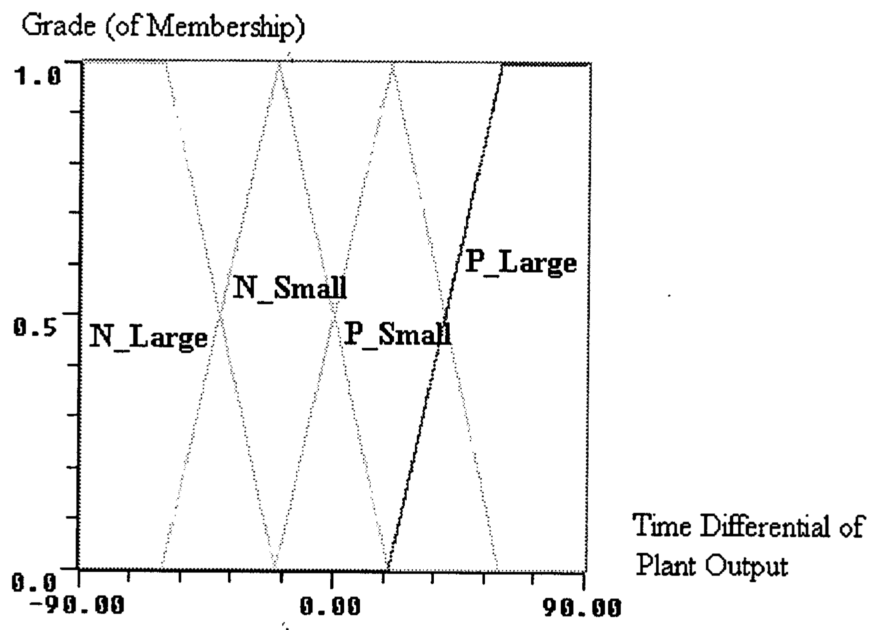
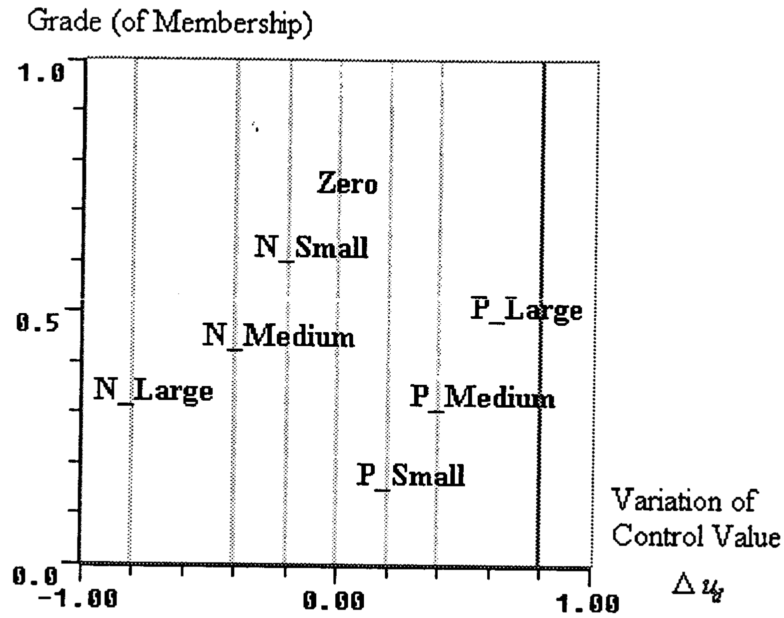


Figure 2c *Labels and Membership Functions of Output Variable* ***Var_Ctrl***



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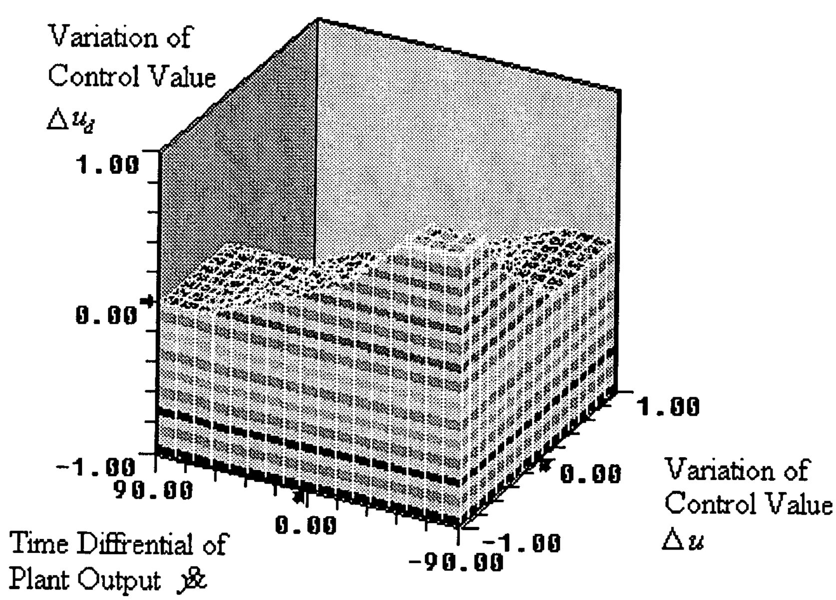
To FIU Source Code for the Dead Time Compensator

Input/Output Response of the Dead Time Compensator

Figure 3 shows the response surface of the dead time compensator. This surface can be obtained by using the Analyzer tool provided in FIDE.

Figure 3 *I/O Response of Dead Time Compensator*



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Input/Output Variables of the Error Compensator

- Labels and membership functions of input/output variables of the Error Compensator are shown in Figure 4a, 4b, 4c.

Figure 4a *Labels and Membership Functions of Input Variable **Error***

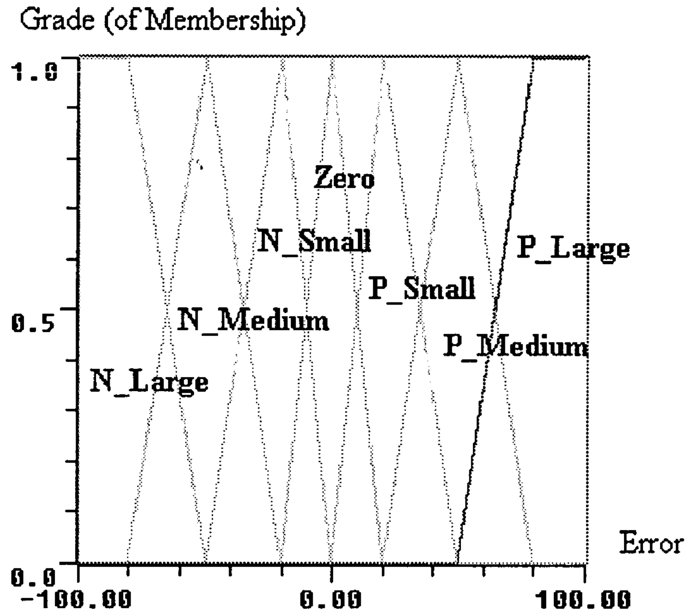


Figure 4b *Labels and Membership Functions of Input Variable **TimeDiff_Error***

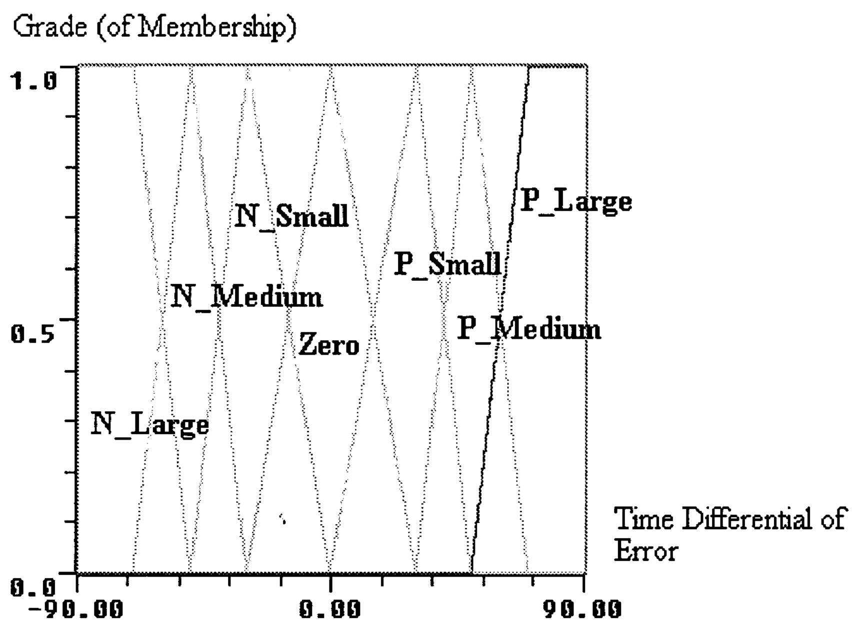
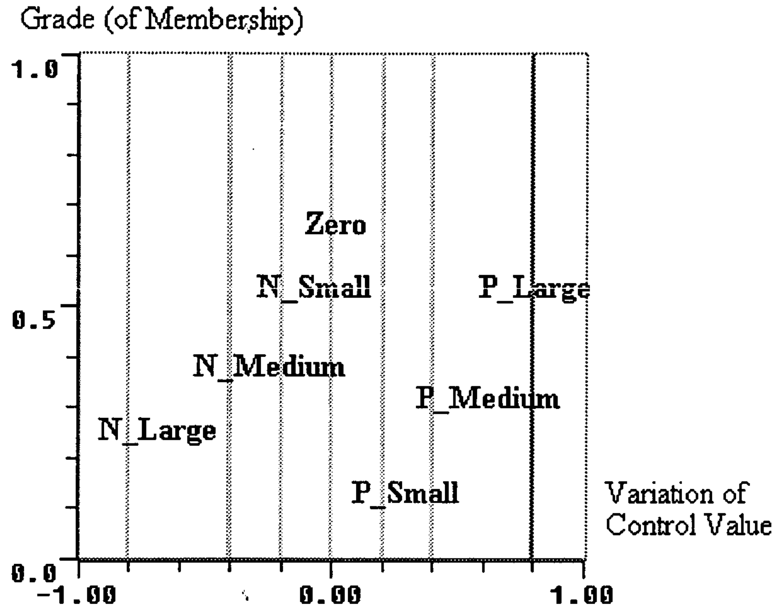


Figure 4c *Labels and Membership Functions of Output Variable **Var_Ctrl***



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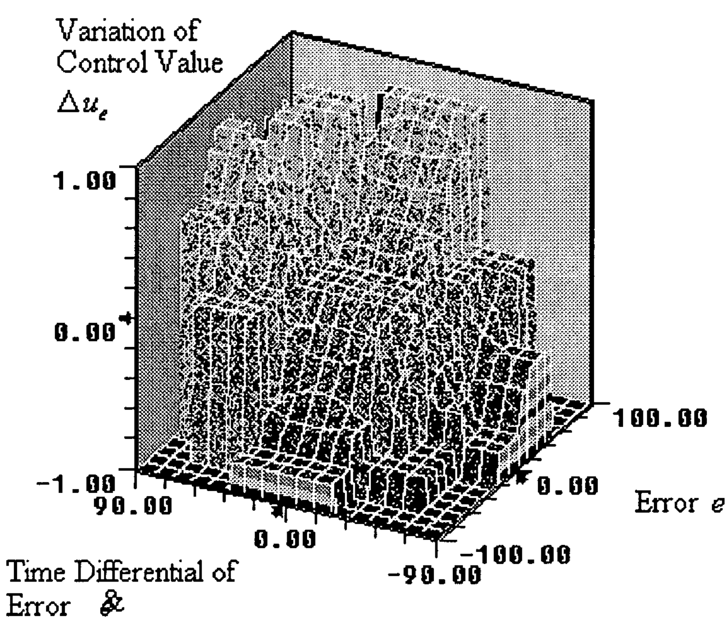
To FIU Source Code of Error Compensator

Input/Output Response of Error Compensator

Figure 5 shows the response surface of the error compensator.

Figure 5 *I/O Response of Error Compensator*



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COMMENTS

Temperature control systems, using fuzzy controllers as shown above, have been put into operation and provide performance better than conventional control systems. Fuzzy controllers also show robust response in the handling of dead time behavior in the process.

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